Opportunities and Challenges

General Comments

HERA

TESLA

Challenges

Albrecht Wagner, Hamburg

General Comments

Progress in experimental particle physics depends on

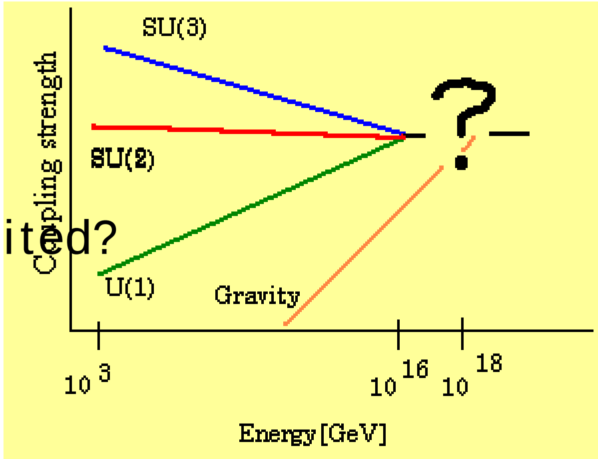
- efficient use of existing facilities (HERA, Tevatron, ...)
- new accelerators at the energy frontier (LHC, e^+e^- colliders, ...)
- b-factories, ...
- high intensity ν-beams
- development of new accelerator technologies
- non-accelerator experiments

i.e. a spectrum of large and not quite so large installations

The Road Map of Particle Physics

Key Questions of Particle Physics

- What is matter ?
- What are the forces ?
- Can quantum physics and general relativity be united?
- What happened in the very early universe ?



Where do the experimental answers lie?

- At highest energies

  Large Hadron Collider — under construction at CERN

- In precision measurements

  Electron-Positron Collider — decide, which project

Physics and experience teach us that we need these different tools to answer these questions and that they complement each other

Need for Long Term Strategy

So far, each lab around the world has proposed, built and operated a given project, sometimes with outside help (HERA, PEP II, LHC)

Sometimes the same kind of accelerator was built in more than one lab (PETRA/PEP, SppS/Tevatron)

Very few projects were not completed

Decisions about projects were taken locally/regionally, but not in a co-ordinated way, based an a far reaching strategy

Why? We did not need to.

Times have changed.

Good example: Astronomy

ALMA

The Atacama Large Millimeter Array (ALMA)

- Merger of the major millimeter array projects into one global project:

- European Large Southern Array
- U.S. Millimeter Array,
- Japanese Array.

- "One of the first truly global projects in the history of fundamental science".

ALMA at Chajnantor
(Courtesy NAOJ)

ESO PR Photo 14/01 (6 April 2001) © European Southern Observatory

LoI signed on 6 April 2001

Opportunity 1: HERA Upgrade

Goals

- increase luminosity by factor 4 - 5 (optics, current)
- collider physics with polarised electrons/positrons

→ 72 new magnets
plus 2 new spin rotators

Physics at high Q^2
integrated Luminosity (electron, positron, different polarisation) : ~ 1 fb^{-1}

start up this fall
main luminosity run until ~ 2006

Opportunity 2: TESLA

~ 1100 participants

Proposal

DESY proposes to

- the international scientific community,
- the German federal government,
- the northern German states

to build TESLA in the vicinity of Hamburg

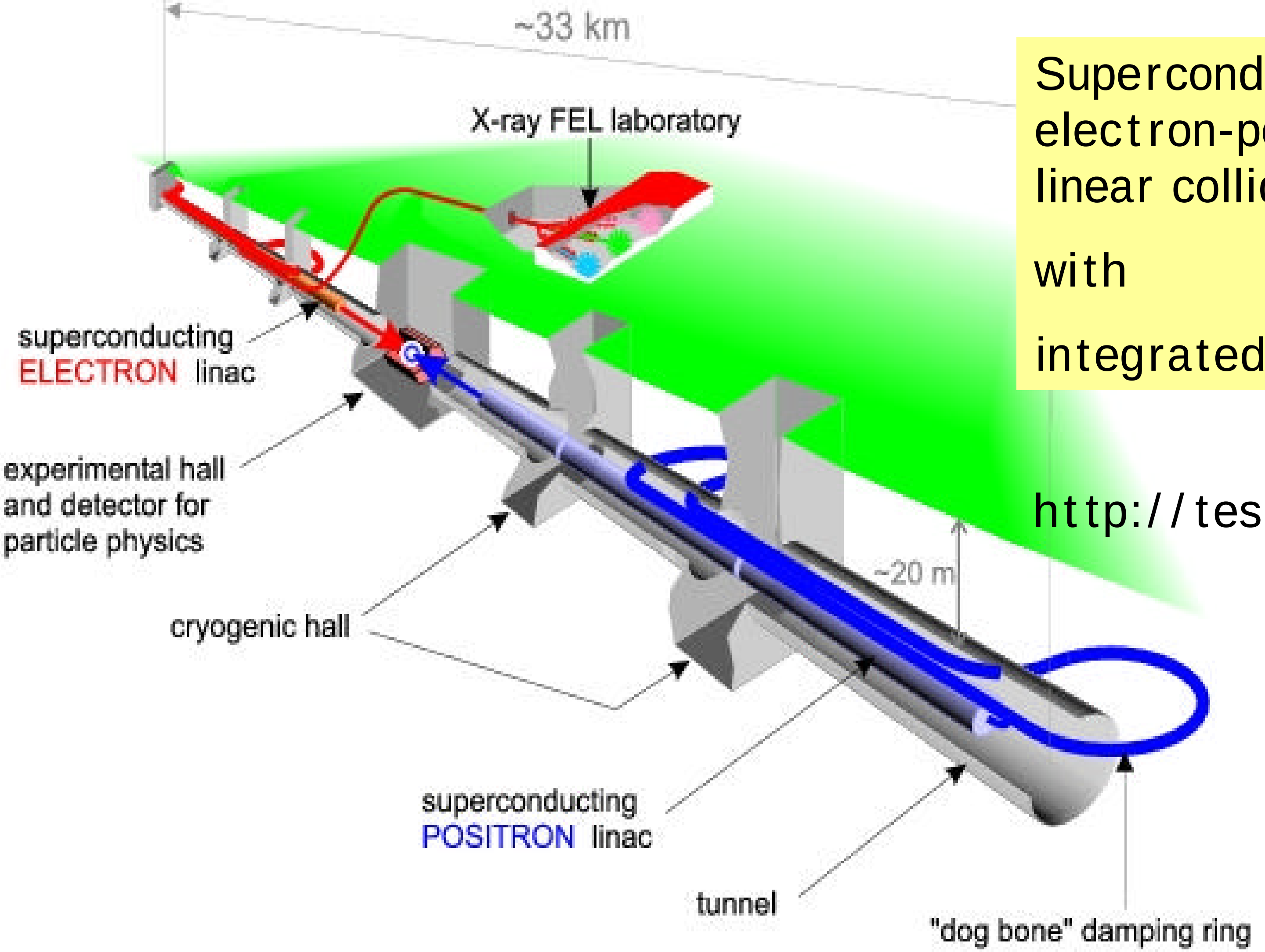
Evaluation by Extended Scientific Council of DESY

Summary

The Technical Design report for the TESLA project has been presented at DESY on March 23/24, 2001. The Extended Scientific Council discussed at its 52nd meeting the Electron-Positron Linear Collider with integrated X-Ray Laser Facility TESLA and came to the following conclusions:

Given the unique possibilities with TESLA to unravel nature's secrets in such diverse fields like particle physics and synchrotron radiation research the Extended Scientific Council fully supports the proposal of DESY to build TESLA within a large international collaboration in the vicinity of Hamburg.

The Project



Superconducting electron-positron linear collider

with

integrated X-ray laser

http://tesla.desy.de

The Authors of the Project

- The TESLA Collaboration:

- more than 40 Institutes in 10 countries

- major hardware contributions from France, Italy, USA and DESY

- Co-operation with CERN, Jlab, KEK on SC cavities

- The Study Groups:

ECFA/DESY Studies

10 XFEL - Workshops

- The Editors

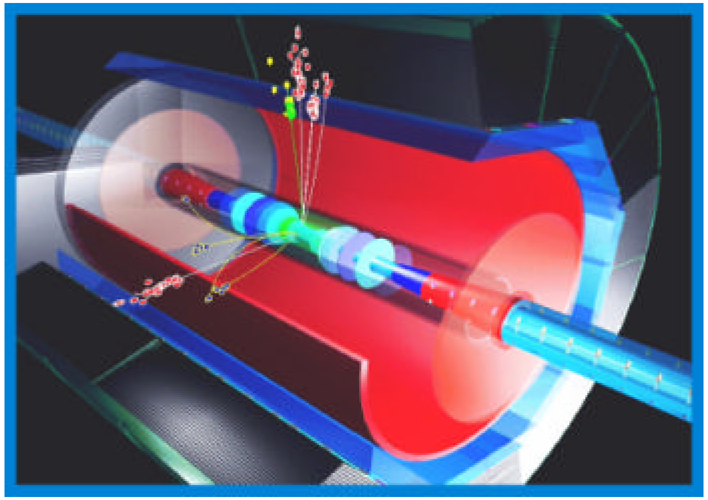
- The Authors of the TDR:

1134 authors from 36 countries

Motivation and Perspectives

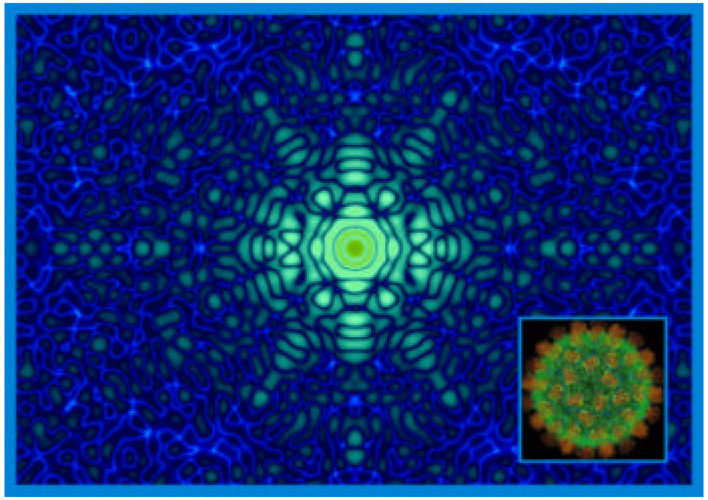
Revealing the Innermost Secrets of the Universe

- Particle Physics
- Cosmology



New Insights into the Facets of Nature and Life

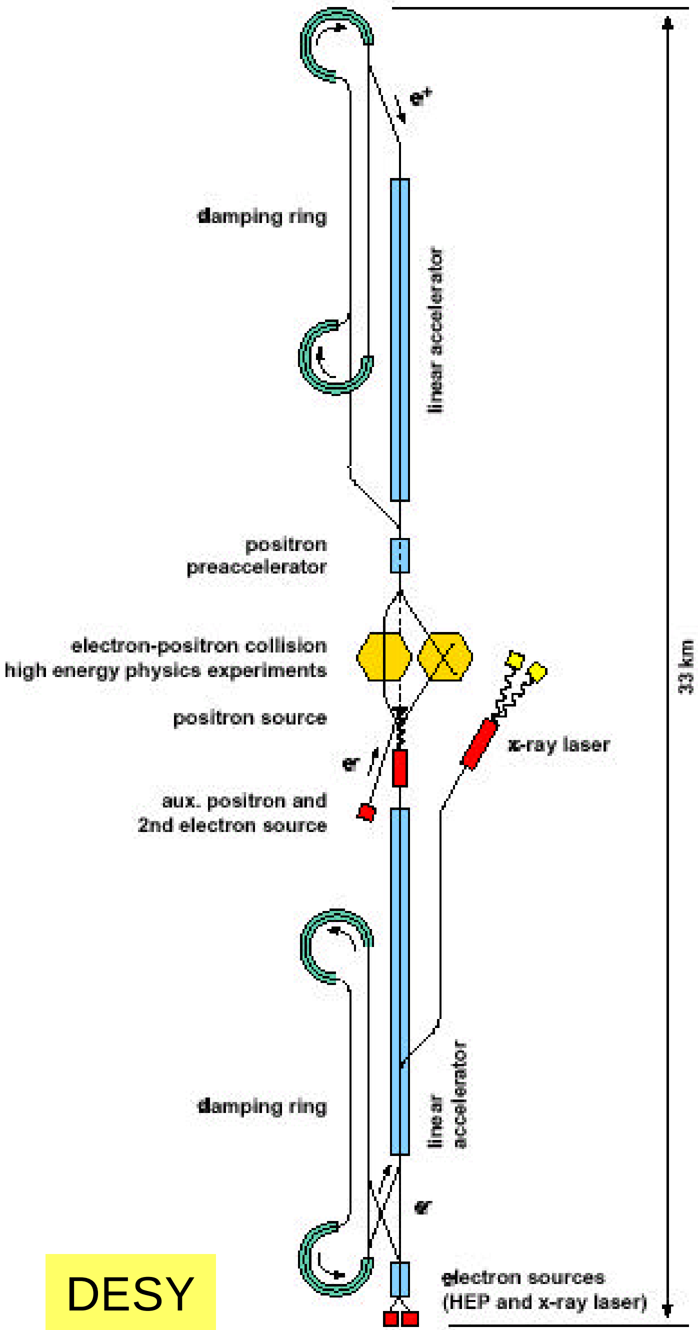
- Physics
- Chemistry
- Life Sciences



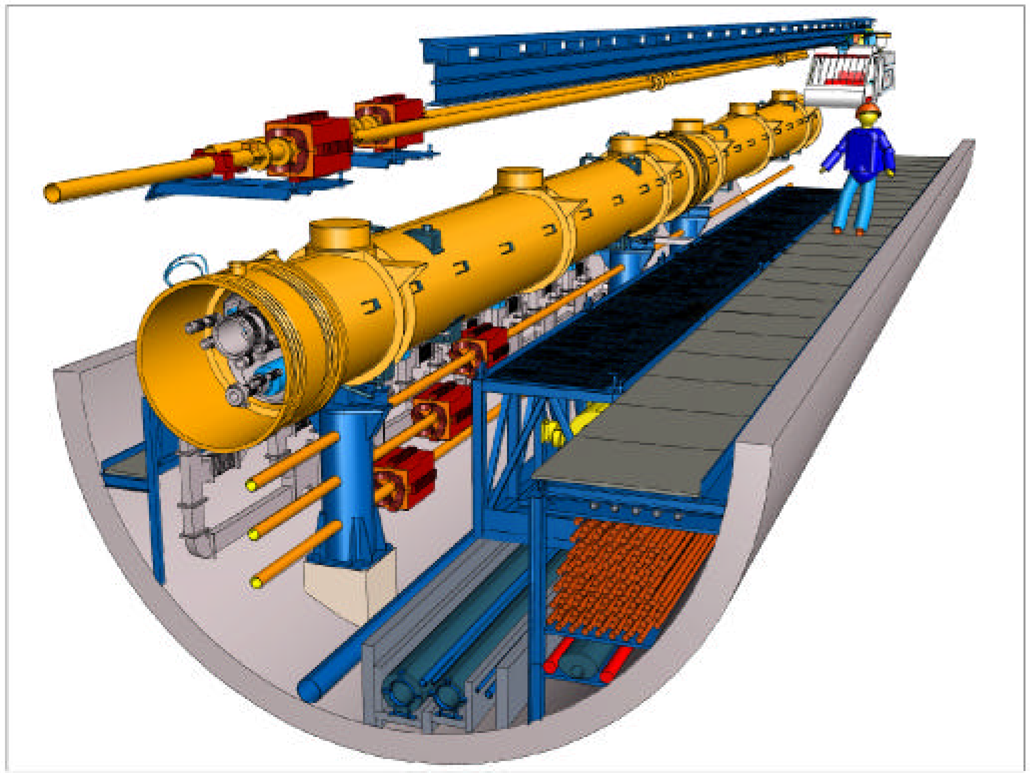
TESLA

The Technical Realisation

See talk by Reinhard Brinkmann



DESY



The Challenge
From SLC to TESLA

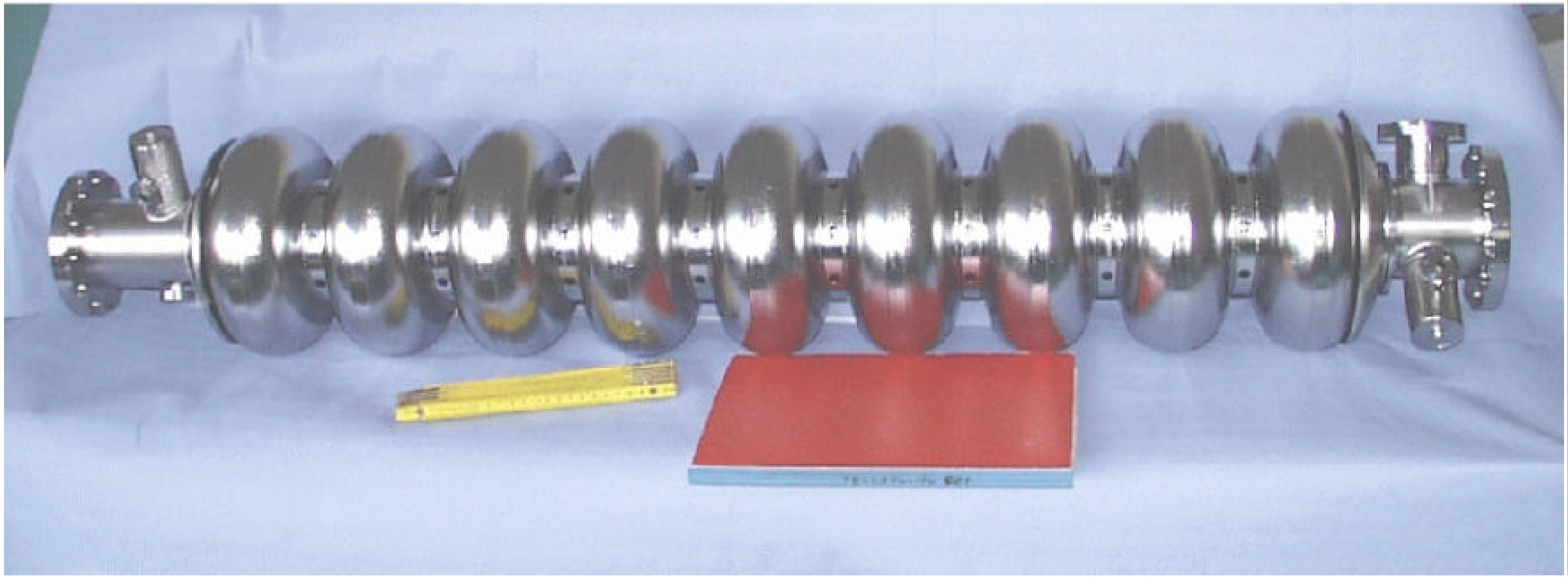
	SLC	TESLA	
Energy E_{cm}	100	500 ($\rightarrow$ ~1000)	GeV
Beam Power	0.04	~10	MW
Spot size at IP	500 (~50§)	~5	nm
Beamstrahlung	0.03	3	%
Luminosity	$3 \cdot 10^{-4}$	3	10^{34} cm^{-2} s^{-1}

- The challenge is luminosity

§ spot size achieved at the Final Focus Test Beam Experiment (international collaboration led by SLAC)

adiabatic damping ~ $E^{1/2}$

SC Cavities



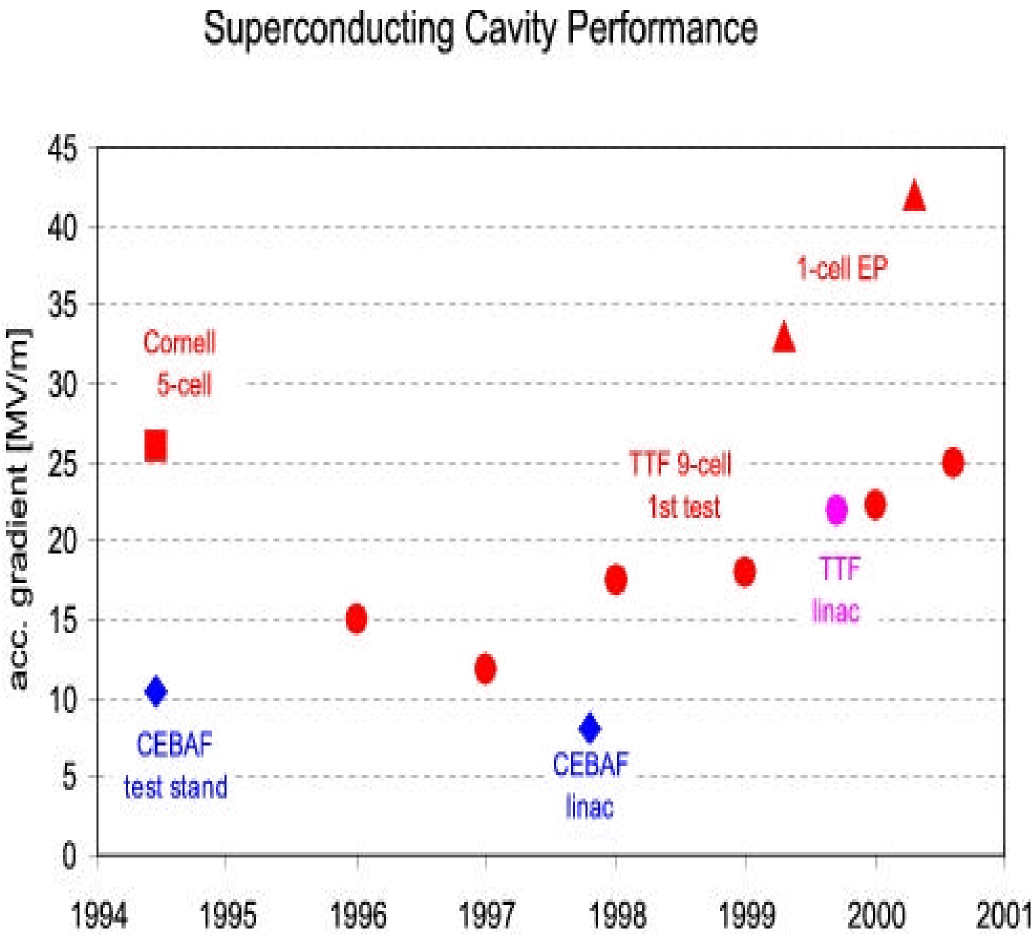
Superconducting solid Nb cavities
T=2K

Long RF pulses (~ 1 ms)
low RF peak power (200 kW/m)
long bunch train with large interbunch spacing
low RF frequency (1.3 GHz), small wakefields

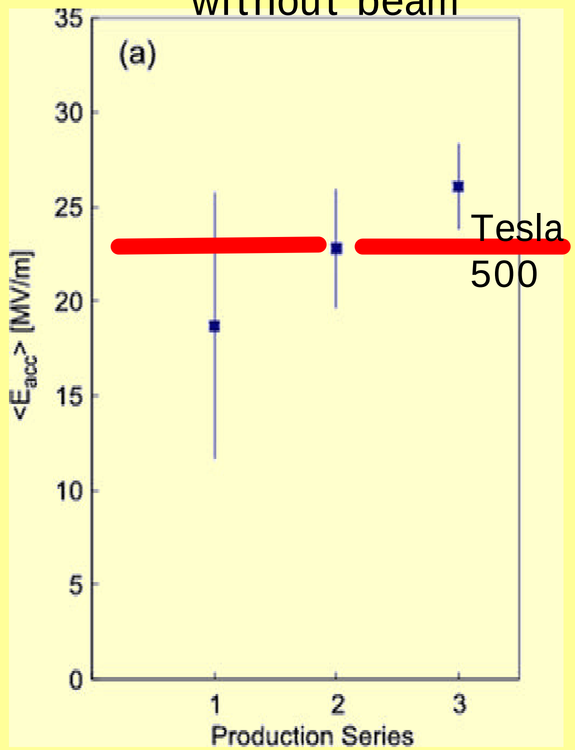
Built so far:
81 9-cell cavities
22 1-cell cavities
6 7-cell cavites
etc

History of Cavity Development

The TESLA Collaboration was able to increase the performance of SC cavities by a factor 4-5 since 1992, while reducing the cost by a factor 4



cavity performance
per production series
without beam



The TESLA Test Facility

Operation for > 3 year
(~ 9000 h)

Test of all components

Proof of SASE principle
around 100 nm

Base for costing

Energy Strategy

- Start with E = 500 GeV

- either: use proven TTF technology (23.4 MV/m)
- or: install cavities with 35 MV/m and 2*9 cells, if ready at construction start

install cooling and RF power for 500 GeV

note: high gradients already being reached with electro-polished cavities

- With (35 MV/m, 2*9 cells) the energy reach is 800 GeV

Operation at 800 GeV requires more RF and cooling power, than installed originally

Beam Delivery System is laid out to accommodate 800 GeV

Path to Higher Energies

1st step: up to ~650 GeV without additional hardware installations, luminosity limited by RF power (beam current & pulse length) and cryogenic plant capacity (rep. rate)

$$L_{650} = 50...70\% \; L_{500} \; (\approx 2 \cdot 10^{34} \text{ cm}^{-2} \text{ s}^{-1})$$

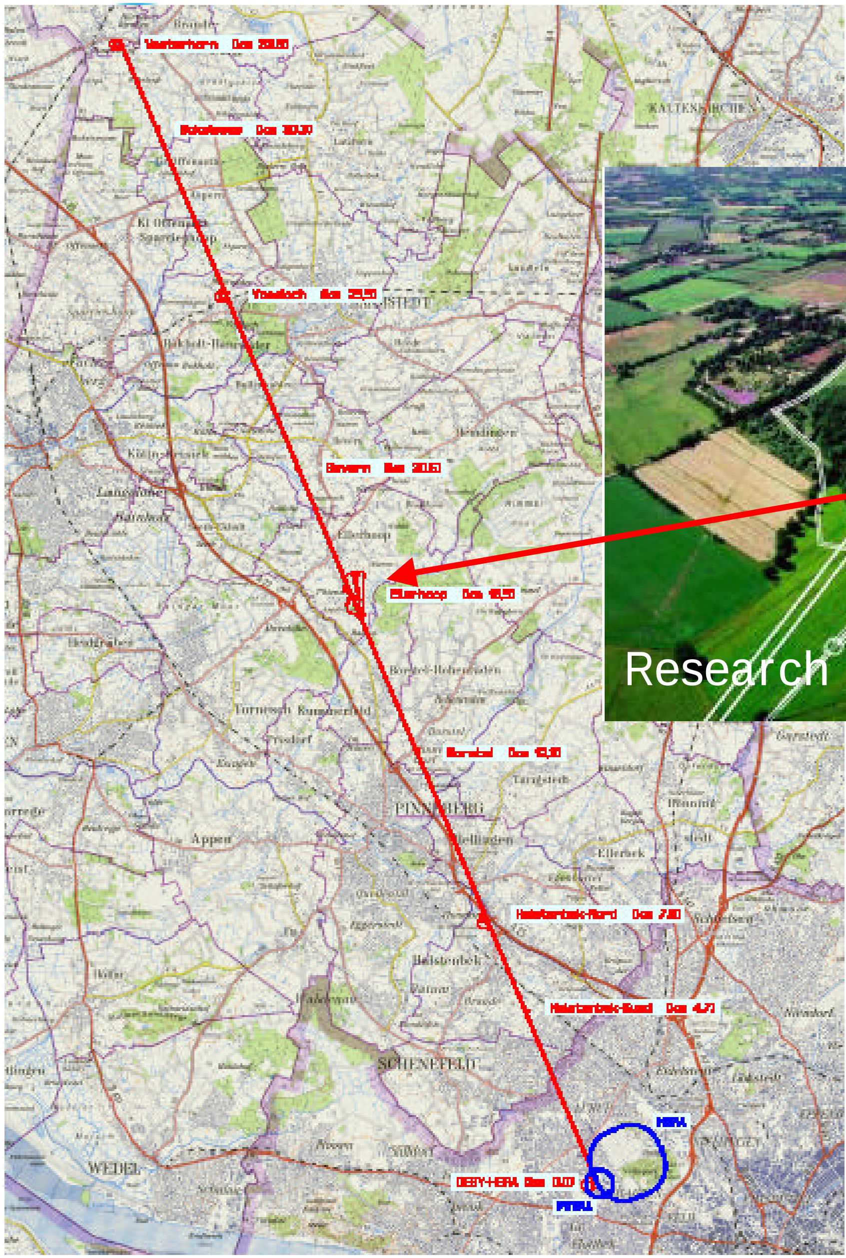
2nd step: doubling of # of RF stations & 2K cryo-plant capacity

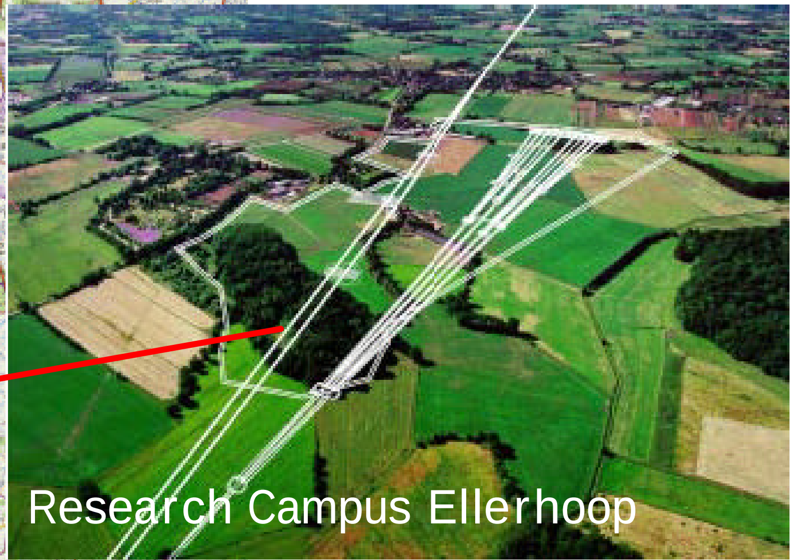
$$L_{800} = 5 \cdot 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$$

Going above 800 GeV:

Should the results from LHC and TESLA clearly indicate that an energy above 800 GeV is needed to answer important questions, and if no other efficient technology is available, it is easy to lengthen the collider

The Site





Two radiological evaluations

Ongoing environmental impact study

Agreement between the states Schleswig-Holstein and HH for joint legal procedure

TESLA CDR had also a site study for Fermilab

The Challenge

How to realise big accelerator projects of the future?

Global Accelerator Network

We need a new approach

What is it?

Collaboration of interested accelerator laboratories and institutes world-wide with the goal to build, operate and utilise large new accelerators

Follows example of major detector collaboration in particle physics

- Partners contribute through components or subsystems
- Facility would be the common property of the participating countries, these would also share the responsibility and cost for operation.

Proposed at the ICFA Seminar at Fermilab, 6.10.1999

see CERN Courier June 2000

Discussion on Tuesday evening

Enabling Large Projects

- make best use of world-wide competence, ideas, resources

- make projects part of the national programs of the participating countries

- create a visible presence of activities in all participating countries

- make site selection less important and controversial *

* Put accelerator at an existing lab: make optimal use of available experience, manpower and infrastructure

Maintaining the Accelerator Culture

- keep culture of accelerator development (scientific and technical) alive in the laboratories and universities, as future accelerators will require substantial advances in technology

- labs need to pursue on a smaller scale also in-house activities while participating actively in a major large facility elsewhere (smaller accelerators, R&D)

- make new projects attractive for young scientists, who can contribute to and participate in large, unique projects

- motivation of staff, effective use of know-how and manpower in all participating labs (without having to relocate people)

- identification of partners with ‘their’ accelerator

Experience from the Past

Accelerators can be built with outside contributions:

- HERA (22% contribution from outside)
- PEP II B- factory
- LHC

- TESLA Test Facility (>40%)

How to build and run an Accelerator?

- design, construction, and testing of components is done in participating institutes

- capital investment is done under the responsibility of the participating institutions/countries (local industry likes this)

- maintain and run accelerators to a large extent remotely, from participating institutions

• centres for remote operation create a clear visibility and demand a commitment from all partners for the duration of project

• highly efficient operation and problem solving around the clock (3 regions cover 24 hours)

From whom can we learn?

- particle physics (e.g. LEP, HERA, LHC experiment controls, TTF etc)
- Japanese synchrotron, which runs under remote control from Tokyo
- automatic beam line controls (synchrotron radiation)
- astronomy (remote operation of telescopes, GEMINI, ALMA)
- space science (Ariane): construction all over Europe, launching in South America, control center in several countries
- space science (shuttle): problem analysis is done on the ground, astronauts are instructed what to do in case of a problem
- industry (e.g. ships, air plane manufacturing, software)

ICFA Study on Global Accelerator Network

Global Considerations
(A. Astbury et al.)

HEP collaborations work on consensus

- takes time
- can produce cost over-runs
- too many funding sources involved

Accelerator collaboration

- lab structure needed
- avoid green field site
- host nation is essential

Remote operation provides
visibility, but not viability

Technical Considerations
(F. Willeke et al.)

Remote operation of accelerators

- good experience with remote operation already
- 90-95% of problems solved w/o expert intervention
- local staff of 100-200 people needed
- Host lab will have safety responsibility
- major challenge social, management, communication

Next Steps - Evaluation

- Submission of TDR for evaluation in Germany by German Science Council (evaluation until summer 2002)
- ECFA Study on long-term perspectives of particle physics in Europe,
- ICFA Technical Review of Linear Collider Technologies (2001)
- Global Science Forum

How to Proceed towards a LC

The scientific community world-wide has to agree (ECFA, HEPAP, Asia) that a Linear Collider

- has an excellent scientific potential in the energy range of 500 - 1000 GeV
- is complementary to LHC
- is the next step on the road map of particle physics, but not the last
- therefore requires a timely realisation

How to Proceed ?

We must therefore

- identify a common accelerator technology and unite behind it (ICFA Technical Review).
- Convince all interested governments to invest in a joint international project, e.g. through the mechanism of a Global Accelerator Network or alike.

The choice of site will be primarily a political decision, determined by which country/region is willing to host the facility. The host has to make a major investment and a long term commitment.

What Needs To Be Done

Define the big goals

Develop from it the long term strategy

Capture the imagination of the public and policy makes

The genuine connection and strengthening link between accelerator particle physics and astrophysics helps

Explain the strategy

Observation: Being interdisciplinary helps

Challenges

We need to find new ways

- to co-ordinate our programs *
- to build and operated new facilities as truly international endeavours: identification with project, not the site lab
- to keep our know-how and base (labs) alive

The time is ripe for a decision about a new facility

We have to solve these issues now

* The decision of the US community / the recommendation of HEPAP concerning the next project will have a direct impact on the programme in the other regions